

## Method and apparatus for processing blood and blood components

The claimed invention relates to a method and an apparatus for pre-processing blood concentrate products before they are exposed to continued processing for extracting those remaining subcomponents that are of interest. The pre-processing of blood concentrate products, primarily pertaining to the invention, entails a resolution of these in a diluting solution and a flushing of the containers or bags in which the blood concentrate products are delivered. This makes possible the following processing operation in the form of centrifuging and the dividing up of blood concentrate products into blood-platelet plasma and waste products.

The invention is primarily intended for pre-processing of such blood concentrate products that are designated "Buffy Coat" at blood-donor centres and which are obtained from red blood cells and plasma from whole blood and which at present are utilised for extracting valuable medicinal blood-platelet plasma. At this stage the Buffy Coat is a thick viscous liquid that must be resolved in a suitable diluting solution before it can be exposed to renewed centrifuging. An example of such a standardised diluting solution, which is widely used, is generally designated T-Sol. In normal cases the Buffy coat is accessible in the form of concentrate from the previous extraction of red blood cells and plasma from whole blood. Each concentrate batch of Buffy Coat is, as a rule, too small to be worth an individual centrifuging after resolution in the current diluting solution. As every Buffy Coat concentrate is initially accessible in its own blood processing bag, a decided amount of diluting solution was previously added manually to each one of a certain amount of blood processing bags and shaken manually until an acceptable mixing had taken place, followed by emptying them together into a larger bag which was then centrifuged.

Apart from the manual handling and the time required for this there is also the added risk to the person who must shake the blood bags and in the long term can receive injury to the neck and shoulders.

To be able to also automate this stage in blood processing it is suggested, in accordance with the claimed invention, the use of a specially intended set of bags preferably containing a ring-shaped bag for the following centrifuging operation as well as the use of a characteristic automatic mixing device, special to the invention, in which the Buffy coat is added and resolved in a diluting solution. In the design of this part of the invention, preferred, by us the mixing function or the mixing device has been built into or made connectable to the outer lid of the centrifuge that is utilised in the processing stage that follows after. Nevertheless, the device can also be made to stand completely by itself without changing the original concept. In the device, in accordance with the invention, a smaller electrically driven motor is thus included which, when the device is combined with the centrifuge, is secured to the lid of the centrifuge. This motor has the distinct feature of never doing a complete revolution in any direction but is quickly stopped before a revolution is completed then followed by an incomplete revolution in the opposite direction. A movement of approximately one of quarter revolution (such as  $+92^\circ$ ), at the most lasting several minutes, has shown that it gives the desired mixing function, which, as shown as follows, has, as its task the replacement of the prior manual resolution of the Buffy Coat and the flushing out of the Buffy Coat bags with the required amount of diluting solution, which, today was generally preceded by Pooling, in other words, the merging of several flushed out quantities of concentrate products to form a mass that is suitable for centrifuging. The device's special movement pattern can be attained with a gear box, a crank function or via the control of its motor. In theory, a hydraulic motor could also be used for this purpose although a longer shaking rate and a longer mixing time should be taken into account. Connected to the aforementioned motor there is a cassette or holder in which the number of concentrate bags with Buffy Coat intended to be included in a process can be connected. Before the concentrate bags are connected to the

cassette they have been individually connected by sterile welding to individual connecting tubes then to the bag set intended for processing, which, in turn, leads to a connecting tube with which all bags containing Buffy Coat can be joined to a bag with the required amount of diluting solution, as well as via a second connecting tube to the ring bag intended for finishing centrifuging and finally to a connecting tube between the ring bag and a storage bag for the desired final product. Together these components make up a functionally sealed system which is easy to handle and completely protected against external bacteria, etc.

When extracting blood platelet plasma from the Buffy coat the number of bags with the original material that are intended for centrifuging are connected to individual connecting tubes in the aforementioned bag set. These connecting tubes are then connected, each in turn, to a multi-way connector to which the connecting tube from the diluting solution bag is also connected. A clamp valve is applied to the latter connecting tube while the bags with Buffy Coat are secured to the aforementioned cassette and the bag with the diluting solution is suspended in the intended holder sufficiently high up to allow the desired amount of diluting solution to be transferred to each respective Buffy Coat bag. The addition of the diluting solution to the Buffy Coat bags is then controlled by the clamp valve, which, in turn, is controlled by a control program that can be included in the control program of the control system of the centrifuge, which also selects the time to start the motor and the time it must be operated. Appropriately, the diluting solution is added in several portions with a motor driven action between each addition. Dissolving the Buffy Coat in the diluting solution is thus carried out without any manual shaking operation. Due to the special timed movement, back and forth, of the motor the problem of damaging the different tubes is avoided. It is only the ring bag and the tube between it and the final product's storage bag that are affected by the mixing operation. After the dissolution of the Buffy Coat in the different exit bags is finalised the content of all bags are added to the bag set included in the ring bag via a separate connecting tube, which also is connected to the previously named multi-way connector and which on its way to the ring bag is placed in a clamp valve by which this connection is controlled. After all substance has been

transferred to the ring bag the connection is interrupted between the ring bag and the exit bags and the diluting solution bag, the appropriate connecting tube is removed by welding from the centrifuge rotor support which it passes, after which the empty bags and their connecting tubes can be rejected. Following this the diluting solution/Buffy Coat mix is centrifuged while the bag intended for storing the end product is located in the centre chamber of the centrifuge rotor. After centrifuging the lighter blood platelet product is transferred to the final storage bag. The designed device is utilised in a known way to expose the ring bag to an outer pressure thus emptying it to a greater or lesser degree. This device consists of a membrane arranged under the ring bag under which hydraulic fluid can be added and therefore expose the ring bag to an external pressure. When emptying the ring bag must be interrupted it is determined by one or more photocells in the outer lid of the centrifuge, which utilise the difference in colour between the light desired blood-platelet's end product and those dark heavy concentrate products that are gathered along the outer periphery. When emptying the ring bag it is suitable to do it via the already described cell trap, which can, for example, be one of the types, described in WO 97/30715. After the desired amount of blood-platelet plasma has been removed from the ring bag the connecting tube between the ring bag and final storage bag is welded in a known way and thereby blocking the ends of both tubes. All that remains after that is to point out that the holder for the diluting solution bag and cassette for the Buffy Coat bags can be made removable in order not to interfere with the other functions of the centrifuge.

The invention in its various functions has now been defined in the subsequent patent claims and they shall now only be somewhat more described in relation to the attached figures.

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Fig. 1 a bag set intended for blood-platelet production from Buffy Coat

Fig. 2 angle projection of the equipped centrifuge in accordance with the invention for autopooping.

The bag shown in Fig. 1 for blood-platelet production from Buffy Coat comprises ring bag 22, a bag for diluting solution 23, four connecting tubes 25–28 (the number of connecting tubes can vary but should as a rule be between 4 and 6), each one is intended for welding to one bag of Buffy Coat, a multi-way connector 29 which, on the one hand, is connected via tube 30 to the diluting solution bag 23 and, on the other hand, to another tube 31 to ring bag 22. From the latter there is one more tube 32 that finally goes to final storage bag 33. In tube 30 connecting to diluting solution 23 there is a breaker switch 45, which, when required to add the diluting solution to tubes 25–28, which are connected to the bags with Buffy Coat, can be opened by sharply bending the tube. Before the breaker switch is opened the connecting tube 30 must be engaged in guide groove 12 in one of the supports 9–11 with which the clamp valve function is intended to control the added diluting solution.

As the bag set shown in Fig 1 is the same as illustrated in Figure 2 we have retained the same notations although the parts are drawn to a smaller scale and consequently also with fewer parts. Otherwise, in Fig. 2 centrifuge 34 is shown standing with its outer lid 35 completely open and locked in position. The inner lid of the centrifuge has not been taken into account in the figure as it made the figure unclear when drawn in position. Also the centrifuge rotor and ring bag 22 has been drawn, to a certain extent, in a simplified way. The control panel of the centrifuge is numbered 36 in the figure. Furthermore, the figure shows a position with four blood bags of Buffy Coat 37–40 suspended in a cassette 41, which is mounted on the outer lid of the centrifuge. The respective outlets of blood bags 37–40 have, by sterile welding, been connected to tube connectors 25–28 and the fluid content of the bags has been transferred to ring bag 22 via these tubes and connecting tube 31. After that, bags 37–40 have received cleaning and diluting fluid from the diluting fluid bag 23 suspended in holder 44. Diluting fluid bag 23 is suspended sufficiently high above bags 37–40 to enable the diluting solution, in sufficient amounts, to be added to the bags as soon as breaker switch 45 in tube 30 and clamp valve in support 11, which tube 30 passes,

is opened. Communication between bags 37–40 and ring bag 22 is via tube 31 which, in turn, passes clamp valve in support 10 by which communication is controlled. As the addition of diluting solution in sufficient amounts to the bags 37–40 starts with the cassette connected motor (not seen on the figure) that operates cassette 41 forwards and backwards in a pendulum movement, in accordance with curve 42, until all the concentrate substance in the Buffy Coat bags has dissolved, after which the built-in clamp valve on support 10 opens up, which outlet tube 31 from multi-way connector 29 passes through and all substance is added to ring bag 22 after which tube 31, in support 10 is sterile welded and blocked whereby the empty bags 37–40 and bag 23 with the concentrate from the diluting solution can be rejected together with the tube system. Flushing out of the blood bags can, if, necessary be carried out as two or several consecutive flushing stages. After the prepared flushing of the blood bags cassette 41 and holder 44 are removed from the centrifuge lid the centrifuge is closed and centrifuging is carried out. Final storage bag 33 is located in centre chamber 45 of the centrifuge. After centrifuging all blood-platelet plasma is transferred to final storage bag 33 via location 5, under the ring bag, being supplied by hydraulic fluid which exposes the bag to an outer pressure which clamps it together. Emptying the ring bag is interrupted by photocell 52 when it registers that the interface between the desired lighter substance and the darker non-desired concentrate product starts to reach the outlet via tube 32. Following this, tube 32 is sterile welded and sealed in one of the supports 9–11, after which the ring bag with the non-desired concentrates of red blood cells, etc. can be rejected.